Segram – a program visualizing stages of grammatical competence

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Introduction
Segram is a computer program constructed to be used in the teaching of courses in grammar and language learning. It is available at the Department of Linguistics, Lund University and can be demonstrated by the authors. It is originally written in Prolog (LPA-Prolog) for Macintosh. It supplements the educational program Gramte (Lastow & Håkansson 1997).

Segram demonstrates the grammatical analysis of Swedish sentences as tree diagrams, parenthesis representations and English translations. Following traditional Swedish grammar, Segram shows two syntactic diagrams, one based on word/phrase classes/categories (Swedish: ordklasser) and one based on functional roles (satsdelar). The trees correspond to parenthesis representations, which are also presented. The functional diagram furthermore shows the meanings of the words given in a kind of Machinese English and the functional representation can therefore be used as an interlingua in automatic translation (see Sigurd 1994).

Segram visualizes mainly grammatical structures. The vocabulary is intentionally very restricted, but the program contains a wide range of syntactic rules. Naturally Segram can only analyze sentences containing words included in its lexicon and only sentences using grammatical constructions included in its grammar.

Segram is constructed to reflect stages in language learning according to Processability theory (Pienemann 1998, Pienemann & Håkansson 1999) and it simulates learner language at different stages by grammars with different sets of rules. The command `analyze1(X)`, where `X` is a string of words, can only analyze sentences which according to Processability theory are available at the first level. The command `analyze2(X)` simulates the second level of processing, etc. Seven levels are assumed. Segram can also generate sentences. The
The lexicon

The present lexicon of Segram is restricted for pedagogical reasons, but it can, of course, be extended. The program contains one intransitive verb sprang 'ran', one transitive verb bet 'bit', one belief verb trodde 'thought', one predicative verb (copula) var 'was' and one auxiliary verb kunde 'could'. All finite verbs in Segram are in the past tense, but there are also two infinite verb forms bita 'bite' and springa 'run', to be used with the auxiliary kunde.

There are several types of adverbials in Segram: a sentence (belief) adverbial (Swedish: satsadverbial) troligen 'probably', one manner adverbial (tidsadverbial) igår 'yesterday', one place adverbial (platsadverbial) på gatan 'in the street', one negative adverbial inte 'not' and the meta comment adverbial minst sagt 'to say the least'. A subordinate clause introduced by när 'when' can also serve as a time adverbial. Segram only accepts two adverbials per sentence, in subordinate sentences generally no adverbials.

There is only one adjective snäll 'nice' which may be an attribute in the form snälla in definite noun phrases: den snälla hunden 'the nice dog', det snälla barnet 'the nice child'. Used predicatively, an adjective has to be inflected according to gender and number in Swedish: barnet var snällt, hunden var snäll. An adjective can also be determined by the adverb (adjective adverb) mycket 'very' in Segram.

For pedagogical reasons the set of nouns is restricted to barnet 'the child', hunden 'the dog', the question pronoun vem 'who' and the personal pronoun hon 'she'/henne 'her'. Segram includes no plural forms.

A noun phrase can only have one attribute beside the article: den snälla hunden 'the nice dog'. The attribute may be a post attribute, either a prepositional phrase: hunden på gatan 'the dog in the street' or a relative clause, as in barnet som hunden bet 'the child that the dog bit'. A relative clause may be a subject relativized clause: hunden som sprang 'the dog that ran' or hunden som bet barnet 'the dog that bit the child'. The object relativized clause is illustrated by barnet som hunden bet 'the child that the dog bit'. Only some simple relative clauses without adverbials can be analyzed in the present version of Segram. The program also includes the subjunction att 'that' introducing subordinate (object) clauses with trodde 'thought'.

Commands

Segram analyzes sentences in general by the command analyze(X), where X is a list of words spelled with no initial capitals and separated by commas as in analyze([den, snälla, hunden, bet, inte, barnet, idag]). If the analysis is to be restricted to a certain level the commands are: analyze1(X) ... analyze7(X).

It is also possible to make Segram generate sentences. The command generate1 will produce sentences acceptable by the first level grammar, generate2 will generate sentences according to the second (and first) level, etc. The highest generate command is generate7, which produces all sentences acceptable at this high level, which includes all the sentences produced at the lower levels (except sentences without inversion after an initial adverbial occurring at the third level). The program can generally give several solutions. One gets the first solution from the program by pressing the button first, next by pressing the button next. If the button all is pressed the computer will generate all sentences of that level - which often will be numerous.

It is also possible to translate between Swedish and English by Segram using the command setrans(X,Y). Writing setrans([[hon,sprang,inte,snabbt]],Y) will result in an English translation (she,did_not,run,quickly) in the variable Y. There is a parallel English grammar in Segram with corresponding words and syntactic rules. The English grammar does not have to handle inversion of subject and predicate if an adverbial introduces the sentence, as the Swedish grammar does, but it has to handle the complications of do-support in negated sentences and questions. The following figures (1 and 2), representations and translation show the analysis of Barnet trodde inte att hunden som sprang var snäll.

Barnet trodde inte att hunden som sprang var snäll

The child did not think that the dog that ran was nice
The rules at the different levels

As mentioned, rules are included or excluded simulating different levels of grammatical competence. The levels programmed are based on Pienemann 1998 and Pienemann & Håkansson 1999. The rules at the lower levels are generally included in the higher levels.

An optional rule is incorporated in the grammar program with a condition, e.g. the following which states that the sentence adverb troligen 'probably' is included only if Segram is ordered to include the fact: lex(trol), which is a characteristic of the sixth level. A condition is written inside curly brackets in Prolog.

sadv(probably, sadv) -> {lex(trol)}, [troligen].

Similarly, if the condition {lex(som))} is fulfilled the system accepts relative clauses, as in barnet som hunden bet, hunden som bet barnet and hunden som sprang. Such relative clauses are not allowed until level 5.

**Level 0 – no grammar**

This level is characterized by the lack of linguistic structure, no morphology, no grammar, i.e. no word inflection, no phrases, no fixed word (phrase) order, no agreement, no subject-predicate structure.

**Level morph**

This pre-grammar level is characterized by some generalized, but not standard Swedish word inflections such as plural -ar, e.g. lamm 'lamb' (normally lamn), husar 'houses' (normally hus), plurals of lamn and hus, respectively. Similarly, verbs are often inflected for past tense by adding -de (-dde after stressed vowel) as in fallde 'fell', springde 'ran', gadde 'went' (to ga), tadde 'took' (to ta), fadde 'got' (to fa). The existence of two different inflection patterns is evidence of the existence of two categories in the learners: verbs and nouns.

**Level 1**

This is the first grammatical level with emerging targetlike nominal and verbal inflection, but only simple noun phrases occur, as in Hund sprang.

**Level 2**

This level is characterized by noun phrases with agreement: (Den) snälla hunden sprang.

**Level 3**

This level allows copulative sentences with var with agreement (Barnet var snäll, Hunden var snäll). Transitive verbs (bet) with objects are allowed (Hunden bet barnet). Auxiliaries (kunde) with infinitives are also accepted. Some second language learners (but not first language learners) accept preposed (topicalized/focused) adverbials of time (igår), place (på gatan) and
manner (snabbt) with non-inverted word order at this level, e.g. Igår hunden bet barnet.

**Level 4**
This level allows preposed adverbs of time (igår), etc., only with inverted word order (Igår bet hunden barnet). Post-attributed prepositional phrases (hunden på gatan) are also accepted. The non-inverted word order acceptable with some learners at level 3 is not accepted at level 4. Inverted word order is used in yes/no questions at this level: Bet hunden barnet? ‘Did the dog bite the child?’.

**Level 5**
Subordinated clauses are a characteristic of this level. Level 5 allows complex noun phrases with relative clauses (pojken som hunden bet). The functional representation of a relative clause repeats the (underlying) correlate. Subordinated att clauses are allowed with the verb trodde. Subordinated clauses are accepted as adverbials, e.g. with the temporal subjunction när ‘when’ as in når hunden sprang.

**Level 6**
The sentence adverbial troligen ‘probably’ which comments on the truth of the sentence is acceptable and regarded as a high degree of competence.

**Level 7**
The metacommenting adverbial phrase minst sagt ‘to say the least’ is a characteristic of level 7 and taken as evidence of a very high degree of grammatical and cognitive competence.

The commands will not accept sentences above the competence indicated by the numbers. The command analyze1([hunden, bet, barnet]) will fail, but analyze3([hunden, bet, barnet]) will be successful and result in a functional representation and tree, a phrase structure representation and tree, a mode label (declarative, decl) and an English translation in the Output window. The sentence [sprang, den, snälla, hunden] will not be accepted below analyze4 as it includes a question with inverse word order. The command analyze5 can analyze [hunden, trodde, att, hunden, som, sprang, bet, barnet, som, barnet, bet, när, hunden, sprang, Igår].

![Figure 3. Functional diagram](image-url)

![Figure 4. Phrase structure diagram](image-url)

The meanings and pragmatics of the sentences may sometimes be strange as also shown by the example Bet den snälla hunden barnet på gatan på gatan. Note the different functions of the preposition phrase på gatan (see Figures 3 and 4).

Bet den snälla hunden barnet på gatan på gatan
Did the nice dog bite the child in the street in the street

Pedagogical use
The system may be used for demonstrating the linguistic structures, terminology and grammatical competence on different levels. It may also be used interactively as in the following questions and instructions to be presented by the computer:

Which categories are demonstrated in the sentence Den näilla hunden var mycket näilla? Which functional roles are demonstrated?

Try to draw the phrase structure tree and the functional tree for the sentence Hunden som sprang bet det näilla barnet.

Which level is demonstrated by the sentence Barnet sade att hunden sprang.

Requires the answer level 5

Which syntactic phenomena are available at level 4?

Which syntactic structures are not acceptable at level 3?

Which is the first level where questions with inverted word order is used?

What is the difference between functional representations and phrase/category representations?

Try to outline the processes that the system must apply in order to arrive at an English translation from a Segram functional (interlingua) representation.

Language acquisition
By associating Segram to the levels of Processability theory it is possible to simulate language acquisition. Segram can therefore give students insights in the language acquisition process. Traditionally, the acquisition of a language is generally seen as a gradual construction of the target grammar from no grammar to a native-like grammar. There is, however, a vast amount of empirical research on developmental levels in the acquisition of Swedish (for an overview, see Pienemann & Håkansson 1999), and these levels are used as a basis for Segram. Segram illustrates the constraints on each level in a clear and consistent way, without the variability which is inherent to natural learner language, and which sometimes makes it hard to see patterns. Since the lexicon of Segram is limited, the grammar can be focussed more clearly.

The grammatical model
Segram assumes (following Chomsky 1957) that it is possible to describe the form and meaning of Swedish sentences by a set of base (kernel) sentences plus a set of transformations. The base sentences of Segram are fixed sequences of noun phrases, verbs, adverb phrases, etc., and the meanings of the base sentences are represented by corresponding sequences of functional roles: subject, object, predicate, adverbials, etc., including word meanings. The base sentences of Segram have VS order, termed ‘inverted’ by Nordic-biased grammarians who regard the SV order as the default. The order in an intransitive base sentence in Segram is: finverb, subj, sentadv, negadv, manneradv, timeadv, placeadv.

The transformations apply to the base sentences in order to get different surface word orders, above all different initial constituents (in the fundament, to use Diderichsen’s term), as topic/focus. The sentence Hunden sprang igår ‘The dog ran yesterday’ thus starts from the base sentence corresponding to sprang hunden igår, from which hunden is preposed. In the sentence Igår sprang hunden, the time adverbial igår has been moved to the front. If nothing is moved to the front a question is generated: Sprang hunden igår?

‘Did the dog run yesterday’.

The inverse basic word order has the advantage that only one movement is required: the movement to the initial position. The subject is already in the position after the finite verb in the base sentence and does not have to be moved from the front to this position.

This approach with underlying verb first is essentially the approach suggested by the Danish grammarian Paul Diderichsen (1946). In Segram the movements only concern the phrase structure representations not the functional representations, where the standard order of Swe tra grammar (see Sigurd 1994) is used. The mode associated with the different transformations is registered.

The analysis of sentences by Segram is similarly done in two steps. If the sentence can be identified with one of the base sentences it is recognized as a yes/no question, if not it is identified as a declarative sentence. Imperative sentences are not covered by Segram. Wh-questions are not registered specially in the present version of Segram.

Sentences with a preposed adverbial immediately followed by the subject, and not by the verb, such as Igår hunden sprang pose a problem to our approach. They are accepted by some learners in the present version at level 3, but not later. Learning the inverse word order is regarded as an important
Programming Segram in Prolog

The grammar in Segram is programmed by generative arrow rules, DCG (Definite Clause Grammar). The sentence arrow rules have additional arguments on the left side of the arrow where the functional representation and the Swedish phrase structure representation to be displayed also as trees, are constructed. The grammar includes phrase and word rules where the word forms and their meanings are shown. The lexicon has to contain inflectional information as well. We will not give all details here.

Agreement in noun phrases is handled by a variable which has the same (or a compatible) value in all the constituents of the noun phrase. On the sentence level, a variable in the subject noun phrase must have the same value as the predicative adjective in Swedish predicative sentences in order to handle agreement. The following is a generative rule showing the base for intransitive predicative adjective in Swedish predicative sentences in order to handle agreement. The following is a generative rule showing the base for intransitive predicative adjective in Swedish predicative sentences in order to handle agreement.

\[
\text{s}([\text{subj}(Nps), \text{pred}(Vi), \text{tadv}([Tadv]), C], \text{verbfras}(Vs), \text{subjnomfras}(Npss), \text{tidsadv}(Tp))) \rightarrow \\
\{\text{C}=[\text{vi}(Vi,Vs), \text{nps}(Nps,Npss,Agr), \text{tadvp}(Tadv,Tp))], \text{noi}(C). \% \text{intrms} \text{with} \text{time adv}
\]

The first square bracket shows the functional representation, the C includes an operational representation which will surface as a string of words by the special predicate nof. The last parenthesis before the arrow includes labels which will appear in the Swedish phrase structure/word/phrase class diagram.

The following rule is a transformation which moves a time adverbial. Items spelled with an initial capital letter are variables in Prolog.

\[
s2(\text{decl,tadv,F,C1,R1}) \rightarrow \{\text{s}(F,C,R,S,[I]), \% \text{take a base sentence}
\text{C}=[\text{vi}(Vi,Vs), \text{member}(\text{tadvp}(Tadv,Ta),T), \text{remove}(\text{tadvp}(Tadv,Ta),T,T2), \text{C1}=[\text{tadvp}(Tadv,Ta),Vi,Ns,T1], \% \text{remove time adv and put it first}
\text{R}=[\text{vi}(Vi,Vs), \text{member}(\text{tadvp}(Tadv,Ta),T), \text{remove}(\text{tadvp}(Tadv,Ta),T,T2), \text{C1}=[\text{tadvp}(Tadv,Ta),Vi,Ns,T1], \% \text{remove time adv and put it first}
\text{R}=[\text{ti}(T1), \text{nol}(C1), \% \text{e.g. Igår sprang hunden}
\]

Grammatical terminology

Swedish grammatical terminology is not completely standardized and some uncertainty is obvious among grammarians, teachers and students. Segram assumes two syntactic representations (trees), a phrase representation and a functional representation and so does the prestigious grammar of the Swedish Academy (SAG 1999). The top node of the phrase representation is sats 'sentence' in SAG and the top node of the functional representation is named mening 'meaning'. Swestra uses s for both representations.

The grammatical terms developed since antiquity do not reflect a well established unified theory. It is clear that some terms reflect a dependency/government/determination/modification/addition relation, where one member is the head of the other(s), which depend on the governor (head) and modify or determine it. Dependency oriented terms are (etymologically) adverb (adding to the verb), adjective (adding to a 'ject': subject or object), attribute/attributive (attributing), determiner (determining the meaning), modifier (modifying the meaning). A determiner of an adjective is traditionally also called an adverb and so is a determiner of an adverb. Segram distinguishes between the adjective adverb (adjadv) and the adverb adverb (advadv).

The phrase category structure terminology can be regarded as an extension of the traditional word class terminology in order to include multiword phrases. Subject and object noun phrases are distinguished in Segram in order to handle word order and the choice between hon 'she' and the object form henne 'her'.

The distinction between phrase and functional representations should ideally correspond to two sets of different terminology, but some terms are lacking in traditional grammar, e.g. functional terms for preposition (etymologically: before position), conjunction and subordinator. The functions of the sentence are traditionally: subject, predicate, direct object, indirect object, adverbial. The noun phrases have typically functions as subject and object and this is reflected in the terms subjnomfras, objnomfras.

The adverbial roles are typically played by adverbs, adverb phrases, prepositional phrases and certain subordinate clauses. The terms for functional roles are signaled by the suffix -al with adverbs: adverb - adverbial. A prepositional phrase may occur in a noun phrase as a post modifier (postattribut) as in hunden på gatan 'the dog in the street'. It is natural to call the heavier noun phrase the head (h) of the prepositional phrase, but one may alternatively argue for the preposition as the head. A similar problem is offered...
by subordinate clauses where the subordinating conjunction or the relative pronoun may be regarded as the head.

We will not discuss these problems further but hope that the terms used in Segram should be acceptable or at least stimulate discussions of grammatical terminology. Students have long requested better grammatical terminology reflecting a unified system which is easier to understand.

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References

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